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Document No. 09-02

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This represents report 09-02 and was supported by the U.S. Department of Defense under work unit 60704. The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the U.S. Government. Approved for public release; distribution is unlimited. This research has been conducted in compliance with all applicable federal regulations governing the protection of human subjects in research.

Abstract

Proper alignment of physical training practices with operational requirements is an ongoing concern for the U.S. Marine Corps. This alignment is being revisited in light of recent combat experiences. Greater emphasis on core strength and power are believed to be needed. A program designed specifically to develop these areas of capability was compared with usual conditioning practices. The Combat Conditioning Trial Program (CCTP) produced gains in core strength and power as intended, with no loss of cardiorespiratory fitness or upper body strength and power. The usual combat conditioning program did produce greater gains in cardiorespiratory fitness, but this trend may have been the result of relatively poor fitness when the study began. The CCTP produced a trend toward lower injury rates. The CCTP achieved its objectives of improving core strength and power without adverse effects on other areas of fitness or injury.

Combat operations in Iraq have raised concerns about the relevance of traditional physical training practices to current needs. Many operations are carried out in urban settings. Personnel must function with heavy loads of equipment, including personal protective armor. Traditional physical training programs may not be aligned with today's combat requirements (Amos, 2006).

A functional fitness concept has been developed to provide the proper alignment of training with operational requirements. Functional fitness is the "…ability to perform a broad array of natural or realistic physical work. For Marines that work involves all the tasks associated with performance in combat" (Amos, 2006). Key elements of the functional fitness concept include:

- Fitness follows combat function.
- Physical training must develop power, strength, flexibility, speed, endurance, agility, and coordination.
- Physical training must have great intensity and variety.
- Physical training must be scalable to individual level and be progressive.
- Training must emphasize "injury proofing" and active recovery.

The concept of functional fitness has been refined to define combat fitness as the goal of physical training. Basic combat fitness is "The minimum maintenance level of individual physical fitness linked to the physical demands associated with Marine Corps service requirements." Beyond this advanced combat fitness is "The level of physical fitness related to operational readiness, which is required to support the unit's operational mission."

The U.S. Marine Corps has developed a trial program corresponding to the combat fitness concept. The present report compares this Combat Conditioning Trial Program (CCTP) with the usual combat conditioning. The CCTP was developed by the U.S. Marine Corps Martial Arts Center for Excellence (MACE), with input from other Marine Corps and civilian physical training experts. The Marine Corps Warfighting Laboratory (MCWL) developed and implemented the plan for evaluating the CCTP.

The Problem of Combat Conditioning

The development of combat fitness concepts has been motivated partly by three perceived limitations of traditional combat conditioning. First, some physical abilities that are essential for effectiveness in today's combat environment receive too little attention. Other abilities, such as cardiovascular endurance, may receive too much attention. Second, physical training tasks fail to mimic key aspects of combat tasks. Combat tasks commonly involve movements that require muscular coordination to support multiplanar movements across multiple joints. The motor patterns for these activities must be learned and practiced to perform these activities efficiently. Traditional training methods, such as weightlifting, are likely to focus on isolated muscle groups with restricted planes of motion. Third, traditional combat conditioning commonly relies on resources that are available in garrison, but not in the field. Weights and pull-up bars

exemplify these resources. Units may not be prepared to train without these resources. As a consequence, training activities may be minimal during deployment, the time that fitness is most needed for effective performance. Functional fitness and combat fitness concepts have been developed to provide guidance in addressing these limitations of traditional combat conditioning.

Comparing Approaches to Combat Conditioning

This project compared combat conditioning linked to the functional fitness concept and usual combat conditioning. Because it compared a trial program and current practices, the comparison was analogous to clinical trials in medicine that compare a new treatment and the current standard of care. The primary hypotheses to be tested were:

- The CCTP will increase functional fitness relative to usual combat conditioning.
- The CCTP will reduce injury rates relative to usual combat conditioning.

The first hypothesis covered a combination of fitness components. The CCTP is not expected to yield superior outcomes for all of those components. Traditional combat conditioning programs produce significant improvements in the physical abilities targeted in those programs. CCTP is not likely to be more effective than usual combat conditioning programs (UCCPs) that have been developed specifically to promote fitness as measured by the U.S. Marine Corps Physical Fitness Test (PFT). However, the CCTP is likely to promote fitness as measured by the U.S. Marine Corps' Combat Fitness Test (CFT). In particular, CCTP can be expected to produce gains in aerobic endurance, upper body strength, and endurance that equal the gains seen in traditional physical training programs. This expectation is based on a recent summary of the effects of U.S. Army Physical Readiness Training (PRT) programs (Vickers, 2007). The pooled results of three studies indicated that improvements in push-ups, sit-ups, and run times were virtually identical in the two programs. Those findings are relevant to the current study because CCTP incorporates some of the general principles guiding the PRT program. The PRT program was based on the principles of progression, variety, and precision:

1. Progression is the gradual increase in total amount of exercise performed. The total can be increased by manipulating the frequency, duration, and intensity of the exercise.
2. Variety is achieved by including different types of training within a program. The types of training should be selected to target each of the major components of physical fitness.
3. Precision focuses on ensuring that exercises are performed properly to train the intended muscle groups and establish proper movement patterns. The program emphasizes proper form (i.e., posture and movement pattern) to achieve this end.

The hypothesis states that the CCTP will be superior to traditional training methods. This assertion is not contrary to the findings from the PRT studies. Those studies relied on the U.S. Army PFT as the sole source of fitness measures. The PFT does

not cover all of the abilities needed for functional fitness. Thus, the CCTP was expected to promote functional fitness more effectively than traditional training because it should develop physical capabilities that are not covered in the PFT. For example, the CCTP was designed to produce greater gains in power, speed, flexibility, and coordination. The overall impact should be an increase in functional fitness even if PFT scores are the same in both training programs.

The second hypothesis was based on the concept of progressive training activities. This hypothesis is consistent with the Army PRT findings. The PRT program reduced overuse injury rates by 48% and traumatic injury rates by 24%. Careful control of the progression of exercise intensity is a likely reason for this reduction. The CCTP includes a similar concept of progression, so it is reasonable to expect similar injury effects.

Methods

Study Populations

Personnel from two USMC battalions participated in the study. One battalion was a Light Armored Reconnaissance (LAR) battalion. The other battalion was an infantry battalion.

Training Programs

Combat Conditioning Trial Program. The different methods of combat conditioning were compared over a 12-week period. During this time, 2nd LAR implemented the CCTP. This program integrated physical conditioning techniques developed to support the Marine Corps Martial Arts Program (MCMAP) with input from various subject matter experts. Information on the general concepts involved and examples of the types of conditioning activities employed can be found at www.tecom.usmc.mil/tbs.

The CCTP consisted of a wide range of activities that varied from day to day (see Appendix A). The CCTP captured the underlying philosophy of the combat conditioning approach to improving fitness. Core strength was emphasized because this characteristic is believed to be essential to effective combat performance. Exercises emphasized multiplanar, multi-joint movements. These exercise movements follow a concept called Martial Skill Transfer. This term has been adopted to emphasize that these exercises are closer to the types of movement required when performing combat tasks than would be the case with typical strength or endurance exercises (e.g., bench presses). The exercises were also designed to require sustained high-intensity exertion to provide power training. This element of the program design was embodied in exercises that required Marines to complete “as many rounds as possible” in a fixed period of time. This element of the program also encouraged Marines to push themselves to the limit regardless of how fit they were.

The selection of specific training activities for the CCTP embodied several basic

precepts of the U.S. Marine Corps approach to combat conditioning. First, Marines must be ready to perform at their best at any time. Programs cannot be designed to produce peak performance at some specific time. Second, programs must develop the full range of physical capabilities required in combat. Combat tasks can vary widely across different settings. Marines must be prepared to meet whatever demands they encounter in combat across all settings and mission objectives. A program that focused solely on developing aerobic endurance, while useful, would be less valuable than one that developed a broader range of capabilities, such as muscle strength and muscular endurance along with aerobic endurance. Third, training routines must be varied. Varying routines ensures that combat conditioning will prepare Marines for all types of combat tasks rather than applying just to that subset of tasks that require movements similar to those required by the specific activity employed in the training program. Systematic variation of training activities is also required to ensure that the conditioning program addresses the intended range of physical abilities. Finally, the program must be viable under field conditions. Marines often spend extended periods in the field. Training resources that are available in garrison often will be unavailable in the field. Training must incorporate field-expedient substitutes for standard equipment to avoid this problem.

The U.S. Marine Corps has developed the Combat Conditioning Exercise Book, which is available from the U.S. Marine Corps Martial Arts Center of Excellence, Quantico, VA, to aid units in implementing combat conditioning programs. The conditioning approach consists of seven general types of activity: core-specific strength training, body weight exercises, buddy exercises, movement exercises, strength training with field equipment, agility and tactical sprints, and barbell exercises. General descriptions of these activities are:

Core-specific strength. Planks, crunches, back bridges, leg raises, and hyperextensions are the major categories of core-specific training activities. The entire torso is conditioned, not just the abdominal musculature.

Body weight exercises and buddy exercises. Push-ups, pull-ups, rope climbs, and squats are examples of body weight exercises. Various methods of lifting a buddy's weight are buddy exercises.

Movement exercises. Movement exercises include the bear walk and crab walk, which are performed with one's own weight, and different methods of carrying or dragging a buddy over a distance.

Strength training with field equipment. This category involves using objects that are routinely available in the field (e.g., sandbags, ammunition cans) to perform familiar weight-training exercises, such as lunges, squats, deadlifts, and presses. Strength training with field equipment also includes explosive power activities that propel a sandbag to a partner, high on a wall, or down to the ground. Catching the sandbag as a partner is another aspect of these exercises.

Agility and tactical sprints. Cone drills, ladder drills, and box jumps are the major activities in this category. Cone drills emphasize movements such as sprinting forward, backing up quickly, and shuffling from side to side. The drills emphasize changing quickly from one direction and type of movement to another. Ladder drills involve moving the feet quickly in and out of a series of squares laid out on the ground. The movements follow a specified pattern of footwork that can be varied to produce different exercises. Box jumps involve jumping onto and off of boxes of different heights in order to achieve a plyometric effect.

Barbell movements. This category includes the correct, safe movements for the back squat, front squat, overhead squat, deadlift, push press, and power clean. These familiar weight-lifting exercises each involve multi-joint, multiplanar movement to promote coordinated strength in different muscle groups.

A wide range of specific combat conditioning programs can be constructed by combining the various options within major types of training activity. Appendix A presents the specific program recommended to the experimental unit in this study.

Usual Combat Conditioning

The infantry battalion followed the usual practice of designing its own combat conditioning program. Training logs were kept that described the specific physical training activities for each day of the 12-week training period. The exercise program for this unit is referred to as the Usual Combat Conditioning Program (UCCP) in the remainder of this report. This label was chosen to reflect the fact that Marines in this unit were also preparing for combat, but were doing so by typical methods used today.

Both units allotted approximately 10 hr per week to physical training. For this reason, the CCTP was designed to consist of five sessions per week, with approximately 1.5 hr per session of actual physical training. The remaining time is for movement to and from the training site and other preparatory activities.

In addition to physical training, each unit engaged in other preparations for deployment. The physical requirements of those preparations will differ for the two units because their combat roles differ. These differences are not expected to affect the impact of physical training during the 12-week comparison period. Unit personnel are expected to adapt to the requirements of their jobs, so any effects of differences in the occupational activities should be minimal.

Physical Fitness Tests

The study units conducted physical fitness tests at the beginning and end of the 12-week training period. The tests included the USMC Physical Fitness Test (PFT), the MACE Combat Conditioning Test (CCT), and rowing ergometry. The PFT consists of sit-ups in 2 min, untimed pull-ups to a maximum of 20, and a timed 3-mi run. The CCT

consists of a 1-mi run, a standing broad jump test (best distance after 3 consecutive jumps), a 300-yd shuttle run with 50-yd increments, push-ups in 1 min, squats in 1min, and a 40-yd dash. These tests assess fitness elements that have been identified as essential for functional fitness (Amos, 2006). Participants also completed 3 bouts on a rowing ergometer. These bouts simulated rowing 500 m, 2 km, and 5 km. The bouts provide assessments of whole-body power output. The PFT and CCT were completed on separate days. The ergometer tests were administered on 2 days with 500-m and 2-kmm tests completed on the same day and a 5-km test on a separate day.

Injury Measures

Electronic treatment records were obtained from the battalion aid station (BAS) for each battalion. Only injury records were extracted from the database. Each record gave the date of the visit and the diagnosis. The records also indicated whether the visit was a follow-up for a previously treated injury. Using this information, an injury episode was defined as all BAS visits made for the same injury. To permit more detailed analyses, the diagnosis was re-coded into injuries affecting the lower body (i.e., ankles, legs, hips) and injuries affecting the upper body and spine (e.g., neck, shoulder, low back pain). Battalion records provided the end strength of the battalion for each month of the study. The injury count for each month was combined with the end strength of each battalion for that month to compute monthly injury rates and odds ratios (ORs). The primary null hypothesis for the statistical tests for injury rates was that the odds of being injured were the same in both battalions (i.e., OR = 1.00). An OR > 1.00 would indicate a higher injury rate in the CCTP unit; an OR < 1.00 would indicate a higher injury rate in the UCCP unit.

Analysis Procedures

Version 16 of SPSS-PC software (SPSS, Inc., Chicago, IL) provided the basic descriptive statistics for the analyses. Descriptive analyses were followed by analyses of covariance (ANCOVAs). ANCOVA was chosen over repeated-measures analysis of variance for two reasons. One reason was that the test conditions differed substantially from the initial testing occasion to the final occasion. Differences in temperature, humidity, and rainfall made the assumption that the tests measured the same performance variables questionable. A difference score would be meaningful only if both tests measured exactly the same construct. ANCOVA rests on the weaker assumption that the pretest is correlated with the posttest score. The second reason was that ANCOVA would yield training effects estimates adjusted for unit differences that existed at the beginning of the study.

The ANCOVA included tests for parallelism of regression lines. In several cases, the regression lines deviated significantly from the assumption of parallelism. For this reason, Rogosa's (1980, 1981) procedures based on Johnson-Neyman regions were used to describe unit differences in fitness scores. These methods accurately assess the average change, even when regression lines are not parallel. When lines are parallel, Rogosa's methods produce the usual adjusted group differences for ANCOVA. This method also

Table 1. Descriptive Statistics for Pretest Measurements

	CCTP			UCCP			
	n	*M*	SD	*n*	Mean	*SD*	*t* test	Sig.
Knees to Elbows (reps)	127	12.17	5.94	91	10.52	5.27	2.12	.035
Broad Jump (in)	127	81.81	8.55	90	82.81	9.06	-0.83	.410
Push-ups (reps)	126	39.08	13.32[a]	91	36.48	9.69	1.66	.098
Squats (reps)	126	44.40	10.00	90	43.12	9.91	.93	.355
1-mi Run (min:s)	128	7:13.0	:39.1	91	7:29.0	:42.6	-2.86	.005
300-yd Shuttle Run (s)	126	58.40	7.02	90	60.88	5.09	-2.86	.005
500-m Row (min:s)	87	1:53.4	10.30	108	1:55.8	11.01	-1.53	.128
2-km Row (min:s)	85	6:41.1	54.85	107	6:43.7	40.41	-.38	.705
5-km Row (min:s)	79	22:37.1	114.06	110	23:27.6	122.75	-2.88	.004
PFT	223	238.40	36.29	108	218.83	36.79	4.58	.000

[a]Variance of CCTP unit significantly ($p < .001$) greater than variance of UCCP unit.

guards against inaccurate estimation when regression lines are not precisely parallel but the sample sizes are too small to detect the deviation. Thus, Rogosa's procedures provided a uniform method of accurately estimating training effects for all of the dependent measures. Appendix B provides details on the computation and form of the Johnson-Neyman regions for this study.

Injury data were analyzed as monthly odds ratios. SPSS cross-tabulations provided the basic information on number of injured and noninjured individuals. An SPSS syntax program converted this information to odds ratios and confidence intervals (Bland & Altman, 2000).

Results

Initial Comparisons

The CCTP unit was more fit when the study began (Table 1). The units differed significantly ($p < .05$) on 5 of 10 test variables. All five significant differences indicated a higher initial fitness in the CCTP unit. The CCTP unit scored higher on knees to elbows (1.65 repetitions) and the PFT (19.6 points). The CCTP unit recorded faster times on the 300-yd shuttle run (2.5 s), the 1-mi run (15.9 s), and the 5-km row (49.4 s).

Variation about the average score generally was comparable across the two units. Tests for homogeneity of variance were nonsignificant ($p > .268$) for 9 of 10 measures. The CCTP unit displayed significantly ($p < .001$) greater variance in push-ups.

Table 2. Adjusted Fitness Differences After Training

	Unit Differences				
Test	*M*	*SD*	*F* test	Sig.	ES[a]
Knees to Elbows	3.89	.41	36.59	.000	0.37
Broad Jump	4.46	.75	26.38	.000	0.49
1-min Squats	4.09	1.90	8.79	.003	0.42
1-min Push-ups	4.69	1.80	12.24	.001	0.48
300-yd Shuttle Run	-.82[b]	.55	1.21	.272[c]	0.16
1-mi Run	.81[b]	25.59	.03	.873	-0.02
500-m Row	2.02[b]	2.18	1.87	.174[c]	-0.18
2-km Row	4.13[b]	30.80	.56	.457	-0.10
5-km Row	32.82[b]	163.82	6.57	.012[c]	-0.27
PFT	-13.31	12.26	14.45	.000[c]	-0.36

[a]ES = Effect size is the mean difference/initial SD for UCCP. The sign of the difference has been reversed for timed variables because higher scores mean poorer performance.
[b]Timed variable. Higher score indicates poorer performance.
[c]Significant Unit x Time interaction in ANCOVA.
Note. Pretest performance was a significant ($p < .001$) predictor of posttest performance for every measure.

Comparison of Training Program Effects

The outcome measures split into two broad groups (Table 2). Figure 1 illustrates the differences. One group of differences consisting of knees to elbows, broad jump, squats, push-ups, and the 300-yd shuttle run favored the CCTP. Except for the shuttle run, the trends favoring the CCTP were statistically significant. The effect sizes were near the upper end of Cohen's (1988) range for small effects (i.e. $.20 \leq |ES| < .50$).

The remaining measures favored the UCCP. These tests included the 1-mi run, the rowing tests, and PFT scores. However, only the differences for the 5-km row and PFT scores were statistically significant. Both of those effect sizes were in Cohen's (1988) small range.

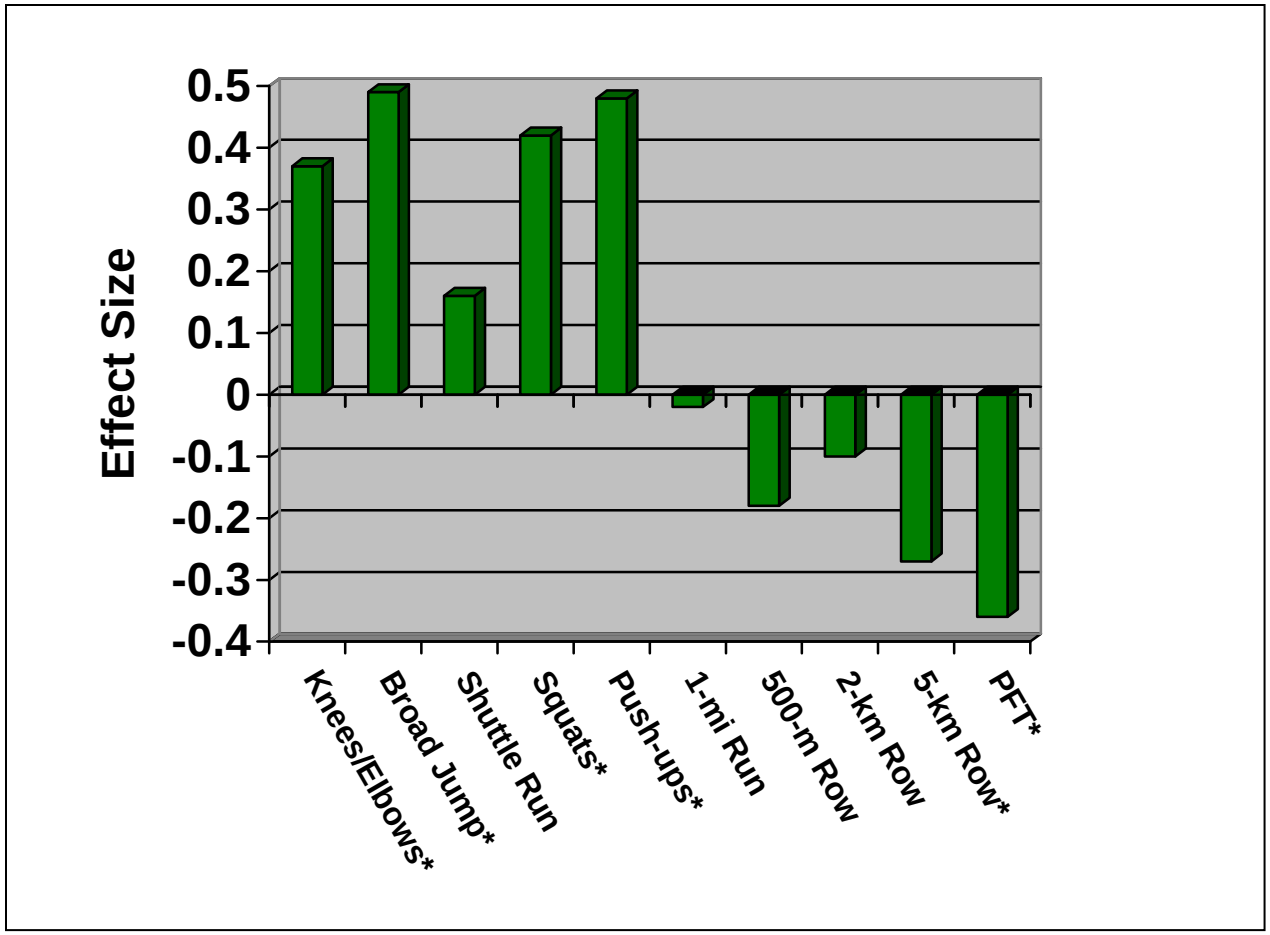

Figure 1. Comparison of training program effects. *Significant ($p < .05$) effect.

Detailed Examination of Cardiorespiratory Fitness

The apparent superiority of the UCCP for promoting aerobic fitness could be an artifact. In military populations, improvement in cardiorespiratory fitness has been linked to initial fitness. The average gains seen in military training units are primarily the result of large gains by the least-fit individuals; individuals who are relatively highly fit initially essentially maintain their fitness. This trend has been evident in at least six studies (Demarle, Heugas, Slawinski, Tricot, Koralsztein, & Billat, 2003; Dyrstad, 2006; Knapik, Bullock, Canada, Toney, Wells, Hoedebecke, et al., 2003; Legaz Arrese, Serrano Ostariz, Casajus Mallen, & Munguia Izquierdo, 2005; Rosendal, Langberg, Skov-Jensen, & Kjaer, 2003; Trank, Ryman, Minagawa, Trone, & Shaffer, 2001).

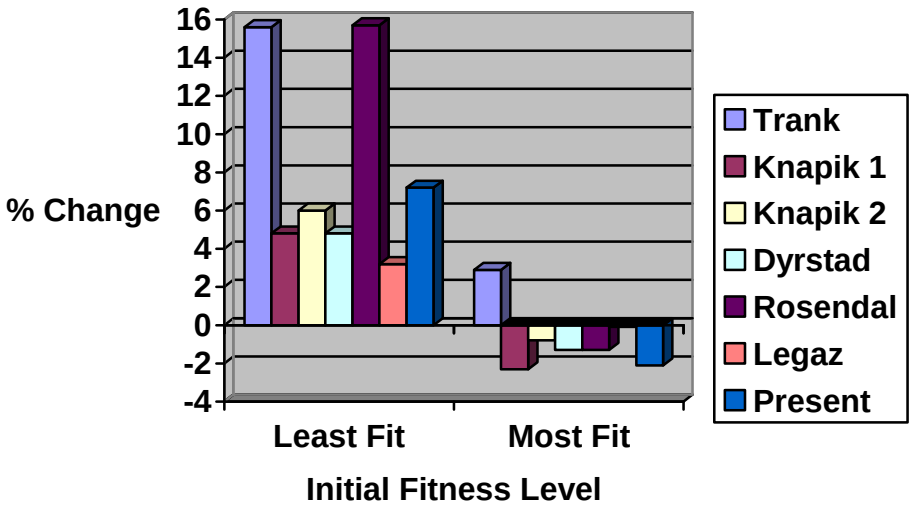

Figure 2. Initial level of cardiorespiratory fitness used as a determinant of training response.

Figure 2 compares the present findings and the results in those studies. The figure contrasts improved cardiorespiratory fitness in trainees who were among the least fit initially (i.e., bottom third or quarter of initial test performance) with slight deterioration in fitness in trainees who were among the most fit initially (i.e., top third or quarter of initial test performance). Across the set of studies, the least-fit trainees improved their test performance by 5.4% (median value; range = 3.2% to 15.8%). The most-fit trainees' test performance declined by 1.1% (median value; range = -1.3% to 2.9%).

Table 3. Comparison of Program Gains on Cardiorespiratory Fitness Indices

	Pretraining		Posttraining			
	M	*SD*	*M*	*SD*	*t* test	Sig.
CCTP unit						
Critical Velocity	3.75	0.35	3.75	0.29	0.09	.927
5-km Row	22:20.4	1:59.1	22:16.4	1:56.7	0.44	.662
PFT	238.40	36.29	239.48	38.62	0.45	.652
UCCP unit						
Critical Velocity	3.51	0.32	3.60	0.28	3.10	.003
5-km Row	23:26.3	2:03.4	22:32.7	1:36.1	6.25	.000
PFT	218.83	36.79	240.27	30.26	10.53	.000

The trend seen in earlier work appears to apply to the participants in the present study. This point was established by using the times for the 3 rowing bouts to estimate critical velocity (CV; Hill, Alain, & Kennedy, 2003). Prior research has established that CV is a valid indicator of cardiorespiratory fitness (Hill, 1993; Vandewalle, Vautier, Kachouri, LeChevalier, & Monod, 1997). Pretest fitness level was defined by splitting the pretest distribution for CV into quartiles. Posttest performance improved 7.2% for participants in the lowest quartile. Posttest performance declined 2.1% participants in the highest quartile.

The effect of initial fitness level on the response to training could account for the observed differences in cardiorespiratory fitness. The CCTP unit was more fit than the UCCP unit at the outset of the study. Individuals in the lowest CV quartile were more common in the usual conditioning unit (38%) than in the CCTP unit (18%). The reverse was true for the highest CV quartile (17% UCCP unit vs. 29% CCTP unit). The differences distribution of fitness levels across the two units were statistically significant ($\chi^2 = 31.59$, 3 *df*, $p < .001$).

The preceding reasoning directed attention to an important trend in the findings. Several tests in the battery should be sensitive to changes in cardiorespiratory fitness. The 3-mi run component of the PFT is an established indicator of cardiorespiratory fitness (Vickers, 2001a, 2001b). This test is one of the primary sources of variation in PFT scores, so PFT scores might show the cardiorespiratory response pattern. The 5-km row is an endurance activity comparable to a 5-km run. This measure, too, could be an indicator of cardiorespiratory fitness. With these points in mind, the lower initial fitness of the UCCP unit might explain the apparently greater improvement on these variables during the study.

The general pattern of differences in Table 3 was consistent with the above reasoning. Cardiorespiratory fitness indicators were virtually unchanged in the CCTP unit. All of those indicators improved significantly in the UCCP unit. When attention is directed to the posttest scores, it is evident that the UCCP unit gains essentially brought them to the level that the CCTP unit maintained throughout the study. Thus, when

absolute cardiorespiratory performance levels are considered, the programs were equivalent at the end of training despite the greater gains produced by UCCP during the study period.

Representativeness of the Test-Retest Participants

The research was conducted on a "not to interfere" basis. This requirement meant that because the participating units had other tasks to carry out at the same time, not all personnel were available for any given testing session. Only a subset of the potential participants was available for both pretest and posttest evaluations. These limitations on availability raised the possibility that people who were available for both sessions were not representative of all potential participants.

Selective attrition would occur if the personnel tested initially but unavailable for the posttest follow-up test differed from people who were available for both tests. This difference in test subjects is referred to as attrition because some participants were lost to follow-up. Attrition would be selective if the losses differed in some way from those who participated at both times. Note that this definition does not include the direction of differences. The differences could indicate that the missing individuals initially were above average as a group.

Differential attrition would affect inferences about program effectiveness. Differential attrition could arise in two ways. In the first case, attrites would show a consistent trend toward higher or lower pretest scores in both units. The effect would be differential if losses were more common in one program than in the other. In the second case, attrites would show different trends in the two programs.

A two-way analysis of variance (ANOVA) assessed these possibilities. All CCTP and UCCP participants involved in the pretest were identified. Those individuals were divided into retained and attrited subsets by determining whether they participated in the posttest. The ANOVA used program membership (CCTP vs. UCCP) and retention status (Retained vs. Attrited) to define the analysis groups. The pretest scores were analyzed using those analysis groups. If attrites differed from retained participants, the effect of retention status would be significant. If attrition effects differed for the two groups, the Program x Retention Status interaction would be significant.

Selective attrition would be inferred if personnel who only participated in the pretest sessions differed from personnel tested at pretest and posttest. None of the 10 tests for selective attrition was significant ($.135 < p < .990$). Differential attrition would be evident if there was an interaction of program with test status. None of the fitness tests displayed evidence of differential attrition ($.131 < p < .980$).

The same issue arose at the end of the training period. Some Marines who had not participated in the initial evaluation provided posttest data. These new participants could differ from the participants who were tested at both times just as attrites could differ from the participants tested at both times. The potential effects of additional test participants

Table 4. Injury Rate by Month by Program

	No. of Injuries		End Strength		Injury Rate[a]	
	UCCP	CCTP	UCCP	CCTP	UCCP	CCTP
August	16	21	775	994	20.6	21.1
September	43	48	812	990	53.0	48.5
October	49	36	826	1001	59.3	36.0

[a]Per 1,000 person-months.

are referred to here as selective recruitment and differential recruitment, respectively.

Recruitment effects were unimportant. In 9 of 10 analyses, ANOVA for the posttest data indicated no evidence of selective recruitment ($.092 < p < .961$) or differential recruitment ($.151 < p < .978$). The 500-m row time showed an effect of adding participants as new test participants performed less well than re-test participants (2:01.8 min vs. 1:51.9 min). However, this addition effect was nearly identical for both units since the interaction of unit with test status did not approach statistical significance ($p = .976$).

The conclusion from these two sets of analyses was that test-retest subjects were representative of their units at both points in time. Only the 500-m row showed any evidence of an effect of restricting attention to those who participated at both times. That difference can reasonably be interpreted as a learning effect for the 500-m row. Individuals with no prior experience were 10 s slower at the end of the study than those who had prior experience on the rower. The 500-m test was scheduled first among the rowing bouts at the beginning and the end of the training period, specifically to provide the opportunity to learn how to row.

Injury Comparisons

Table 4 and Figure 3 (p. 14) present the basic data for injury rate comparisons. Injury rates are expressed as the number of injuries per 1000 person-months of risk exposure. If the 3 months of the study were representative of the full year, the annual injury rate for the CCTP would be 21% lower than the annual injury rate for usual training (i.e., 422.4 injuries per 1000 person-years vs. 531.6 injuries per 1000 person-years).

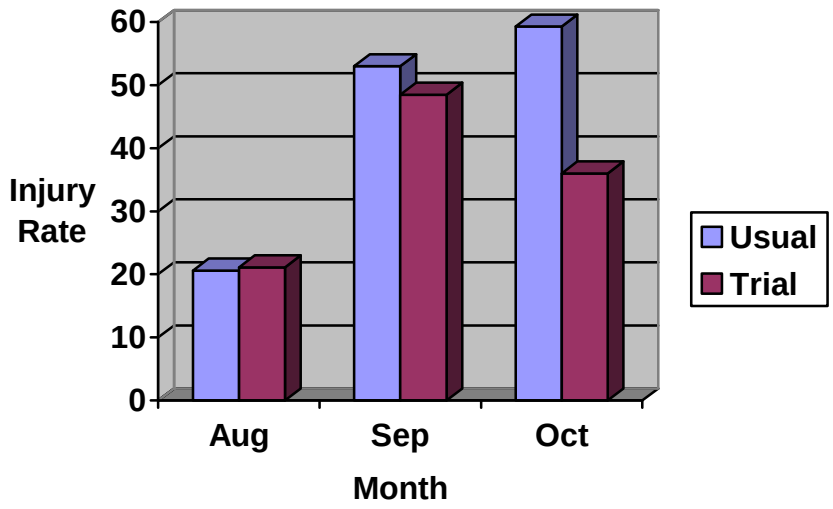

Figure 3. Injury rate per 1000 person-months.

Table 5 provides the results of statistical tests comparing the training programs based on the odds of being injured in each program. The two training programs produced virtually identical odds for injury in August. September odds were slightly lower for the CCTP, but the difference was not significant because OR = 1.00 still fell within the 95% confidence interval. October odds were significantly ($p < .05$) lower for the CCTP, but the effect size underlying this significance test fell in the range that Cohen (1988) classifies as small, but potentially important, for theory or application.

Table 5. Odds Ratios for Injuries

		95% Confidence Interval		
	Odds Ratio	Lower Bound	Upper Bound	Effect Size
August	1.02	.53	1.98	.01
September	.91	.60	1.39	-.05
October	.59	.38	.92	.29
Pooled	.78	.60	1.03	-.13

[a]Effect Size = ln(odds ratio)/1.81; see Chinn (2000).

Table 6. Injury Location by Program

	CCTP		UCCP	
	Number	Percent	Number	Percent
Upper body	43	40.6%	45	43.3%
Lower body	63	59.4%	59	56.7%

Note. χ^2 corrected for continuity = 0.07, 1 *df*, $p = .797$.

The pooled injury rate for the 3-month period must be viewed with some caution. The computation of this rate treated each month of exposure for an individual as independent of his prior exposure. If the independence assumption is invalid, the degrees of freedom in the data are overestimated, thereby making the significance test too lenient.

When the independence assumption was treated as reasonable, the cumulative data indicated a lower injury rate for the CCTP (OR = .78). The difference in odds of injury approached significance ($z = 1.74$, $p = .082$), but the effect size was barely above Cohen's (1988) lower bound for small, but potentially important, effects (i.e., $|ES| = .10$). Thus, even this lenient approach to the overall data for the training period suggests that injury rate differences were minor.

Injury rate data were examined in more detail to determine whether the training produced different types of injury. Injuries were classified as upper body or lower body for this purpose. The evidence indicated that the proportions of upper body versus lower body injuries were comparable for the two programs (Table 6).

The distributions of injuries might differ over time. For example, the UCCP might initially produce more injuries to hips, legs, and ankles. The CCTP might initially produce more injuries to the arms, shoulders, and back. A month-by-month comparison of the number of upper and lower body injuries within the programs provided no support for this speculation regarding the distribution of injuries over time. In every case, the χ^2 for a given month was less than 1.00 ($.02 \leq \chi^2 \leq .87$), so none of the differences approached statistical significance ($.889 \geq p \geq .350$).

Discussion

The CCTP and the UCCP regimens both improved fitness. The areas of improvement differed between the programs. The CCTP improved core strength (e.g., knees to elbows) and power (e.g., standing broad jump). The UCCP promoted cardiorespiratory endurance gains (e.g., 5-km row). The differential effects suggest two points. First, the specificity principle of physical training may be at play here. Fitness gains are seen primarily in specific capabilities that are targeted by the training program. The known tendency for traditional training programs to focus on endurance and upper body strength is one reason for current concerns about how well those programs prepare Marines for combat. Specificity considerations in turn suggest that the training programs

examined here have complementary roles in combat readiness. Usual training provides the basic fitness needed for good health and to meet minimal occupational standards. The training provided by the CCTP can build on this basic fitness to enhance physical capabilities that are essential for optimal combat performance. This point is indicated by the fact that the CCTP maintained an initially high level of performance in the areas targeted by current training programs at the same time that the CCTP improved other physical capabilities.

The injury data slightly favored the CCTP over the UCCP. The trend was weak and should be viewed with caution. The conclusion that the programs differed rests on month-by-month comparisons. The trend from equal injury rates to lower rates in the CCTP was consistent and strong enough to produce a significant difference by the end of the training period. The reason for caution is that this treatment of the data involved a series of month-by-month significance tests. When multiple significance tests are performed, the likelihood that at least one test will be significant by chance alone increases. A simple method of adjusting for this tendency is to define an acceptable error rate for the full set of tests and divide that rate by the number of tests performed. The resulting error rate sets a more extreme significance criterion. The individual tests are conducted using this extreme criterion. Applying this approach to the injury data, the significance criterion for the individual tests would have to be $p < .017$ to keep the overall error rate at $p < .05$. None of the odds ratios in Table 4 would have satisfied this criterion. Therefore, the strongest inference that can be drawn from the injury data with statistical confidence is that the CCTP did not increase the injury rate. The fact that the UCCP participants were less fit than the CCTP participants initially provides another point to consider. Perhaps injuries simply are more likely when less-fit populations are exposed to training rigors. Finally, the CCTP was implemented in a graded fashion, with careful attention to controlling injury risk. This aspect of the CCTP may have been less pronounced in the UCCP. Taking these considerations into account, the hypothesis that the CCTP lowers injury rates is not unreasonable, but more data would be needed to adequately evaluate this possibility.

Factors that might weaken the conclusions drawn from the data must be considered. Information presented in the Results section of this report helps rule out two possible problems. The Marines who contributed data to the inferences about program effects were representative of their units at the beginning and the end of training. The sample sizes were large enough to detect small effects. This point is obvious from the fact that the significant differences in fitness at the end of the study translated into effect sizes that Cohen (1988) would classify as small. The most problematic element of the design is that the units were not equally fit at the beginning of the study. If the UCCP unit had been as fit as the CCTP unit, it is conceivable that usual practices would have produced no increases in fitness at all. On the other hand, if both units had been at the initial level of fitness for the UCCP unit, it is possible that the CCTP training would have produced a higher injury rate. Finally, possible limitations of the dependent variables merit consideration. The ultimate goal of combat conditioning is to prepare the Marines for effective combat performance. The field fitness tests used in this study are not direct indicators of combat fitness. These tests have a plausible relationship to improved

readiness and performance because they are logically related to physical capabilities that are believed to be important for effectiveness in the type of combat conditions encountered by Marines today. While it is likely that direct study of this issue would verify the expert opinions that went into the design of the CCTP and the selection of outcome measures, the conclusion that the CCTP actually improves combat performance should be regarded as tentative.

To summarize briefly, this evaluation compared a new physical training program designed to promote core strength and upper and lower body power to usual training practices. The new program improved the targeted capabilities while maintaining endurance capabilities and did so without increasing injury rates. The CCTP may not fully supplant current training practices since that training may be necessary to achieve the fitness needed to prepare Marines so that they can safely achieve the benefits provided by the CCTP.

Acknowledgements

The authors thank the officers and men of the 2nd Light Armored Reconnaissance Battalion and the 2nd Battalion, 9th Marines, 2nd Marine Division for their participation in this study. Joseph C. Shusko's comments on an earlier draft of this paper were appreciated.

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Appendix A. Recommended Combat Conditioning Program

The design of the recommended Combat Conditioning Trial Program (CCTP) embodied the underlying principles of combat conditioning. First, elements were chosen to develop the broad spectrum of abilities needed for combat effectiveness. Activities that targeted different abilities, such as strength, power, and endurance, were scheduled systematically. Second, the specific workout activities that targeted a given ability were varied over time. This variation ensured that the program developed a general capability instead of the ability to perform a specific training task. Third, workouts that could be performed in the field were emphasized. This emphasis is important to ensure that Marines can take their conditioning program with them wherever they go. In combination, these principles led to a complex training schedule. Table A-1 shows the recommended schedule for physical training that embodied this approach.

The details of the specific activities are less important than the mixture of different training components. For this reason, the program description provided here emphasizes the general types of exercise recommended to the CCTP unit over the specifics of day-to-day exercises. It is assumed that common physical fitness activities, such as push-ups, pull-ups, squats, runs, and marches, are self-explanatory.

One general principle of the program should be noted before describing the general categories of exercise. For exercises using weights or other objects, the exercises always are performed with submaximal weights. This point is clear when it is noted that the Marine is expected to complete multiple repetitions of the exercise. The training effect sometimes is achieved by completing a prescribed number of sets of the exercise. Having the Marine complete 5 sets of 3 repetitions of the deadlift is one example. More often, the training effect is achieved by having the Marine complete as many sets as possible within a given time period. When this approach is used, each set consists of multiple activities. Having the Marine complete a fixed number of pull-ups followed by a fixed number of thrusters that involve lifting a weight above the head is an example. The general principle is that each set of exercises is performed long enough to task the endurance capacities of the involved muscle groups. Endurance is further emphasized by the requirement that the individual repeat the set as many times as possible within a specified time.

Each day's exercise program included activities that comprised four exercise categories: dynamic warm-ups, core-specific training, an event, and a cool-down (Table A-1). Most of the major components of each activity category are widely used physical training activities. Major types of activity that may not be widely familiar include:

> *Warm-ups*. The warm-up exercises include drills designed to increase quickness, agility, and efficiency of movement. Ladder drills are foot movement drills performed with a ladder on the ground. The feet move in and out of the spaces between rungs in a specified pattern as quickly as possible. Cone drills involve moving through a set of cones in a specified pattern. The typical pattern involves rapid forward movement, rapid backward movement, and shuffling

movements to the right and left. Exercises such as the falling start into a sprint are self-explanatory. The warm-ups consisted of unweighted practice of the movement patterns required by weight-lifting exercises when those exercises were part of the day's program.

Crunch/Hyperextension Exercises. In crunch exercises, participants lie on their backs and contract their abdominal muscles. The contractions can be achieved by raising the shoulders, raising the legs, or raising both shoulders and legs. Exercises can be varied by changing the end position of the shoulders and legs. In hyperextension exercises, participants lie on their stomachs and contract their back muscles. Contractions are achieved by raising the shoulders, raising the legs, or both. Torso rotation can be added to further vary the hyperextensions.

Buddy Exercises. Marines work in pairs to perform these exercises. One Marine serves as an anchor or weight for the other Marine. Hanging guard sit-ups are an example of an anchor exercise. One Marine assumes a stable stance facing the other Marine. The second Marine locks his legs around the waist of the first Marine and lets his torso hang down. The exercise consists of raising the torso upright. Buddy-weight exercises are straightforward. One Marine is used as a weight for the other Marine. The Marine serving as a weight may be carried (e.g., fireman's carry), dragged, or lifted (e.g., by his belt) to exercise different muscle groups.

Medicine Ball Exercises. These exercises use a medicine ball or similar object, such as a sandbag to achieve a proprioceptive (the body acting as a single unit) movement. The ball may be lifted, pushed, or thrown. Different muscle groups can be stressed by varying the motions. For example, having two individuals stand back to back and pass the ball in a circle about them will work the muscles of the torso and back. Push passes to another Marine or upward to a target on a wall will develop explosive strength of the arms and upper body. In addition to these uses of the medicine ball, the program included simple deadlifts of the ball, sit-ups with the ball, and other activities. Most of those activities primarily stressed the muscles of the upper body. The ball can be used for movements that simulate lifting overhead, twisting to hand an object to a second person, chopping, and propelling a weighted object up or out using movements similar to a basketball chest pass.

Planks. Plank exercises involve holding one's body weight off the ground. Planks can be performed in a position similar to the push-up. In this position, both elbows are on the ground. The upper arm is perpendicular to the ground. The body is held rigid, maintaining a straight line from head to toe. This position is held for as long as possible or until told to stop. Planks also can be performed with the Marine on his side. In this case, weight rests on either the right or left elbow. The upper part of the arm that is holding the body off the ground is perpendicular to the ground. The body is held rigid, with a straight line from head to toe.

Thrusters. This exercise begins with the Marine in a standing position. A barbell or other weight is held at shoulder height across the chest. The Marine then drops into a squatting position, with the weight remaining across the chest. The exercise is completed by driving explosively with the legs and arms to move from the squat position to a standing position with the weight above the head, arms fully extended. The weight then is dropped to the chest to return to the starting position. This sequence constitutes 1 repetition.

Weightlifting Exercises. The weightlifting exercises in the program emphasize movements through a distance. The movements involve multiple joints (e.g., knee, hip, ankle, shoulder) and multiplanar movements of the weights. In the push press, for example, the Marine has a weight at shoulder height, then quickly flexes the knees and hips, and lifts the weight overhead by extending arms and legs. Other familiar exercises in this group include deadlifts, squats, snatches, and power clean. Squats can be performed with the weight resting behind the head on the shoulder, held at shoulder height in front of the head, or held overhead. In each case, the weights involved are less than maximal, so the Marine can perform multiple repetitions. The use of any of these exercises is preceded by a review of the proper form for the exercise. The review reduces the risk of injury.

Cool-down Exercises. These exercises, which are conducted at the end of each session, emphasize stretching the muscles. Static stretching involves gradually easing into the stretch position and holding the position. Stretches should be held for 10 s as part of cooling down. Dynamic range-of-motion (DROM) stretching consists of controlled leg and arm swings that take the exerciser gently to the limits of his/her range of motion. When it is necessary to perform dynamic movements, it is appropriate to conduct dynamic stretching exercises. Proprioceptive neuromuscular facilitation (PNF) stretching involves the use of muscle contraction to achieve maximum muscle relaxation. The Marine moves into a position that provides a stretch sensation for the targeted muscle(s). A partner holds the limb in this stretched position while the Marine pushes against the partner’s resistance for 6 to 10 s. The partner then moves the limb into a further stretch and the process is repeated through 3 or 4 cycles.

Table A-1 provides the recommended combat conditioning program.

Table A-1. Recommended Physical Training Program

Week 1	Monday	Tuesday	Wednesday	Thursday	Friday
Dynamic Warm-up	Front Skip Slow Carioca, Dot/Cross Drill	High Foot Lunge Lateral Jumping Jacks Jumping and Landing Drills	Running Mechanics Drills	Front Skips A-skips forward A-skips lateral	Agility Ladder 2 in, 2 out Zig Zag Nike Shuffle
Core Specific	Plank Position	Crunch/ Hyperextension Series	1.5 mi run (Boots and Utilities)	For Time – - Run 400 m - 21 pull-ups - 9 reps of 65 lb thruster - Run 400 m - 15 pull-ups - 15 reps of 65 lb thruster - Run 400 m - 9 pull-ups - 21 reps 65 lb thruster	For Time - 3 Mi Ruck March with 40 lb Pack - Push-up/Squat with pack series
Event	For time - - 800 m run - 25 medicine ball clean and jerk - 600 m run - 50 med ball deadlifts - 400 m run - 75 med ball squats (hugging ball)	Complete as many rounds as possible in 20 min: - 65 lb push-press, 12 reps - 10 pull-ups	Buddy Exercise Abdomen Series	Med ball Sit & Reach Crazy Eights Bicycles	None
Cool Down	PNF Stretching	DROM Stretching	Static Stretching	DROM Stretching	PNF Stretching
Compare to	20 lb Sandbag for med ball	Complete as many rounds as possible in 20 min: - 20 sandbag swings - 10 pull-ups	Same as above	Use 30 lb sandbag for thrusters x 30	Same as above

Table A – 1. Recommended Physical Training Program (continued)

Week 2	Monday	Tuesday	Wednesday	Thursday	Friday
Dynamic Warm Up	Cone Box Drills	Front Skip High foot lunge Falling start sprint	Running mechanics drills	Agility Ladder 2 in, 2 out/ 2 scissors/ jump scotch	A-Skips Lateral A-skips Falling start sprint
Core Specific	Plank Position	Med ball Core Series	Run 3 mi	Five rounds for time of: - 15 reps 95 lb deadlift - Run 400 m - 15 sit-ups	Five rounds for time 3-minute break between rounds: - 20 pull-ups - 30 push-ups - 40 sit-ups - 50 squats
Event	Complete as many rounds as possible in 20 min: - 5 pull-ups - 10 push-ups - 15 squat	Five rounds for time of: - Run 400 m - 25 reps of kettle bell/ Dumbell Swings	Buddy Exercise Abdomen Series	None	None
Cool Down	PNF Stretching	DROM Stretching	PNF Stretching	DROM Stretching	Static stretching
Compare to	Same as Above	Five rounds for time of: - Single arm sandbag cleans x 30 each arm - Run 400 m	Same as above	Five rounds for time of: - Buddy Deadlift x 20 - Run 400 m - 15 sit-ups	Same as above

Table A – 1. Recommended Physical Training Program (continued)

Week 3	Monday	Tuesday	Wednesday	Thursday	Friday
Dynamic Warm Up	A-Skips Lateral A-skips Vertical skips Falling starts	Deadlift review/ROM	Clean and jerk odd objects	Bear crawl Crab walk 10 yd pack strap carry	Cone “K” Drill (with and without packs)
Event	Complete as many rounds as possible in 20 min: - 10 reps of 35 lb dumbbell/kettle bell snatch left arm - 10 reps of 35 lb dumbbell/kettle bell snatch right arm - 12 pull-ups	None	For time - - 50 24” high box jumps - 50 burpees, jumping to 12“ above reach - 50 ball slams, 20 lb ball - 50 wall balls, 20 lb ball target 10’ above ground - 50 ball cleans, 20 lb ball	Crunch/ Hyperextension Series	5 Mi Ruck March with 50 lb pack
Core Specific	Plank Position	Deadlift 5-5-5-5-5	Buddy Exercise Abdomen Series	Complete as many rounds as possible in 20 min: - 5 handstand push-ups - 15 pull-ups - 25 squats	Med ball Core Series
Cool Down	Buddy-assisted Stretching	Static Stretching	DROM Stretching	PNF Stretching	PNF Stretching
Compare to	Complete as many rounds as possible in 20 min: - Sandbag snatch x 15 - 12 pull-ups	3 rounds for time: - 5 buddy squats - 10 buddy D Deadlifts - 5 bridle curls or 5 axles	For time: - 50 sandbag med ball star jumps - 50 burpees - 50 sandbag med ball slams - 50 sandbag wall balls - 50 sandbag cleans	Same As Above	Same as above

Table A – 1. Recommended Physical Training Program (continued)

Week4	Monday	Tuesday	Wednesday	Thursday	Friday
Dynamic Warm Up	High Foot Lunge Lateral Jumping Jacks Jumping and Landing drills	Cone Box Drill	Running mechanics drills	Snatch review Range of Motion	Front Skip Slow Carioca Dot/Cross Drill
Event	Total time for rounds of 21,15 and 9 reps of: - 95 lb barbell thruster - Pull-ups	Crunch/ Hyperextension Series	Med ball Core Series	4 reps of maximum Dumbbell/ Kettle bell swings	For time – - 100 pull-ups - 100 push-ups - 100 sit-ups - 100 squats
Core Specific	Plank Position	Three rounds for time of: - 400 m run - 21 reps of 50 lb dumbbell/ kettle bell swing - 12 pull-ups	9:00 min of Walk/Jog/Sprint Intervals	Plank Position	None
Cool Down	PNF Stretching	DROM Stretching	DROM Stretching	Static Stretching	PNF Stretching
Compare to	50, 40, 30 reps of: - Sandbag thrusters - Pull-ups	Three rounds for time of: - 400 m run - 30 Sandbag swings - 12 pull-ups	Same as above	Axles 5-5-5-5-5	Same as above

Table A – 1. Recommended Physical Training Program (continued)

Week 5	Monday	Tuesday	Wednesday	Thursday	Friday
Dynamic Warm Up	Deadlift review Range of Motion	Agility ladder 2 in, 2 out 2 in scissors jump scotch	Front squat review Range of Motion	Agility Ladder 2 in,2out Zig zag Nike Shuffle	Snatch review Range of Motion
Event	Deadlift 3-3-3-3-3	Rounds of 15-12-9-6 and 3 reps for total time of: - 185 lb deadlift - Handstand push-ups (Buddy Asst as reqd)	Front squat 5-5-5-5-5	Buddy Exercise Abdomen Series	4 sets of maximum number of reps of Dumbbell/ Kettle bell swings
Core Specific	None	None	Medicine Ball Sit & Reach Crazy Eights Bicycles	Five rounds for time of: - Run 400 m - 30 24” box jumps - 30 20 lb wall-ball shots, target 10 ft above ground	Plank Position
Cool Down	Buddy Asst Stretching	Buddy Asst Stretching	PNF Stretching	DROM Stretching	Static Stretching
Compare to	Buddy Deadlift 5-5-5-5-5 Add flaks and hold sandbags for additional weights	Sets of 15-12-9-6-3 reps for time: - Buddy Deadlift - Handstand push-ups	Buddy Squat 5-5-5-5-5 Add flaks	Five rounds for time: - 50 m Buddy carry (Fireman’s, pack strap, cross-body) - 15 Burpees - 20 Sandbag wall-ball	Axles 5-5-5-5-5

Table A – 1. Recommended Physical Training Program (continued)

Week 6	Monday	Tuesday	Wednesday	Thursday	Friday
Dynamic Warm Up	Cone Box Drill	Running Mechanics Drills	Agility Ladder 2 in, 2 out/2 in scissors/jump scotch	Back squat review/Range of Motion	Box Drill with and without packs
Event	Complete as many rounds as possible in 20 min: - 21 Sit-ups - 21 Back Extensions	Med ball core series	21-18-15-12-9-6 and 3 rep rounds for total time of: - 45 lb overhead squat - Sit-ups	Back squat 3-3-3-3-3	6 mi Ruck March with 60 lb pack
Core Specific	None	4 mi run in boots and utilities	None	Crunch/ Hyperextension Series	Plank Position
Cool Down	Static Stretching	Buddy-assisted Stretching	Static Stretching	PNF Stretching	Static Stretching
Compare to	Same as above	Same as above	30-25-20-15-10-5 reps of: - Sandbag lunge steps - Sit-ups	Buddy Squats 5-5-5-5-5 Add flaks	All Buddy Carries for 50 m or Same as above

Table A – 1. Recommended Physical Training Program (continued)

Week 7	Monday	Tuesday	Wednesday	Thursday	Friday
Dynamic Warm Up	A-Skips Lateral A-skips Vertical skips Falling starts	I Test Shuttle Test	Deadlift review Range of Motion	Agility Ladder 2 in,2out Zig zag Nike Shuffle	Running Mechanics Drills
Event	Five rounds for time of: - 15 reps of Dumbbell/ Kettle bell Swings - 20 reps of 20 lb wall ball, target ten ft above ground	For time - - 15 handstand push-ups - 3 L pull-ups - 12 handstand push-ups - 6 L pull-ups - 9 handstand push-ups - 9 L pull-ups - 6 handstand push-ups - 12 L pull-ups - 3 handstand push-ups - 15 L pull-ups	Deadlift 1-1-1-1-1	For time - - Run 400 m - 95 lb thruster, 21 reps - 30 pull-ups - Run 800 m - 30 pull-ups - 21 reps 95 lb thruster - Run 400 m	Med Ball Core series
Core Specific	Crunch/ Hyperextension Series	None	Med ball Sit & Reach Crazy Eights Bicycles	Buddy Exercises Abdomen Series	2 x 9:00 min PT Gear Walk/Jog/Sprint Intervals
Cool Down	DROM	PNF Stretching	Buddy Asst Stretching	DROM Stretching	PNF Stretching
Compare to	Five rounds for time: - 10 Buddy Squats - 20 Sandbag star jumps	Same as above	Buddy Deadlifts 10-10-10-10-10 Add Flacks, Packs and sandbags	30 thrusters with 30 lb sandbag	Same as above

Table A – 1. Recommended Physical Training Program (continued)

Week 8	Monday	Tuesday	Wednesday	Thursday	Friday
Dynamic Warm Up	Front Skip Slow Carioca Dot/Cross Drill	Jog Deep squats	Bear crawl Crab walk 10 yd pack strap carry	High Foot Lunge Lateral Jumping Jacks Jumping and Landing drills	Bear crawl Crab walk 10 yd pack strap carry
Core Specific	Plank Position	Crunch/ Hyperextension Series	Buddy Exercises Abdomen series	Five rounds for time of: - 15 reps, 95 lb thruster - Run 400 m	Three rounds for time of: - Run 600 m - 5 series of 5 pull-ups, 10 push-ups, and 15 squats
Event	Lunge 400 m (multiply steps by the time to completion rounded to nearest .5 min.)	Complete as many rounds as possible in 20 min: - 7 Handstand push-ups - 10 pull-ups	Run 4 mi in boots and utilities	Med ball core series	Plank Position
Cool Down	Static Stretching	DROM Stretching	PNF Stretching	Buddy-assisted Stretching	PNF Stretching
Compare to	Lunge 200 m carrying sandbag or same as above	Same as Above	Same as above	20 Sandbag Star jumps - Run 400 m	Same As Above

Table A – 1. Recommended Physical Training Program (continued)

Week 9	Monday	Tuesday	Wednesday	Thursday	Friday
Dynamic Warm Up	Agility Ladder 2 in,2out Zig zag Nike Shuffle	Agility Ladder 2 in, 2 out 2 in scissors jump scotch	Running Mechanics Drills	Deadlift review ROM	Bear crawl Crab walk 10 yd pack strap carry
Event	21-18-15-12-9 reps for total time of 95 lb: - Deadlift - Hang power clean - Front squat - Push-jerk	Med ball Sit & Reach Crazy Eights Bicycles	L-Pull-ups 3 sets of 10 knees to elbows	Deadlift 3-3-3-3-3	Crunch/ Hyperextension Series
Core Specific	Plank Position	Three rounds for time of: - 50 Squats - Run 800 m	Run 3 mi PT Gear	Med ball Abdomen series	Complete as many rounds as possible in 20 min: - 10 pull-ups - 20 push-ups
Cool Down	DROM Stretching	PNF Stretching	PNF Stretching	DROM Stretching	Static Stretching
Compare to	Sets of 21-18-15-12-9 reps of - Buddy Deadlift - Axles - Buddy Squats - Buddy Push-ups	Same As Above	Same as above	Buddy Deadlift 5-5-5-5-5 Buddy Squats 5-5-5-5-5 Add flaks and hold sandbags	Same as above

Table A – 1. Recommended Physical Training Program (continued)

Week 10	Monday	Tuesday	Wednesday	Thursday	Friday
Dynamic Warm Up	I Test Shuttle Test	Front Skip Slow Carioca Dot/Cross Drill	Bear crawl Crab walk 10 yd pack strap carry	Cone “K” Drill	Jog
Event	100 Pull-ups for time	Three rounds for time of: - 50 Sit-ups - 30 Back Extensions	Crunch/ Hyperextension series	100 Burpees, jumping to 8 ft reach height for time	2 x 9:00 min Boots and Utilities Walk/Jog/Sprint Intervals
Core Specific	Buddy Exercises Abdomen series	None	Run 1.5 mi Boots and Utilities	None	Med ball Core series
Cool Down	Static Stretching	DROM Stretching	PNF Stretching	DROM Stretching	PNF Stretching
Compare to	Same as Above	Same as Above	Same as above	Same as Above	Same as above

Table A – 1. Recommended Physical Training Program (continued)

Week 11	Monday	Tuesday	Wednesday	Thursday	Friday
Dynamic Warm Up	Back squat review ROM	Running Mechanics Drills	Agility Ladder 2 in,2out Zig zag Nike Shuffle	Cone Box Drills	A-Skips Lateral A-skips Vertical skips Falling starts
Event	Back Squat 1-1-1-1-1	Med ball Core Series	Complete as many rounds as possible in 20 min: - 12 reps of Dumbbell / Kettle bell Swings - 12 pull-ups	Five rounds for time of: - 15 reps of 95 lb Push jerk - 30 Sit-ups - Run 400 m	Crunch/ Hyperextension series
Core Specific	None	Run 5 mi in boots and utilities	Buddy Exercises Core Series	None	Ten rounds for time of: - Lunge 10 steps - 20 push-ups
Cool Down	Buddy Asst stretching	Static stretching	PNF Stretching	Static stretching	DROM Stretching
Compare to	Buddy Deadlift 5-5-5-5-5 Buddy Squats 5-5-5-5-5 Axles 5-5-5-5-5 Add flaks and hold sandbags for Deadlift and Squat	Same as Above	Complete as many rounds as possible in 20 min: - 7 Axles - 12 Pull-ups	Sets of 50, 40, 30 reps of: - Sandbag thrusters - Sit-ups	Same as above

Table A – 1. Recommended Physical Training Program (continued)

Week 12	Monday	Tuesday	Wednesday	Thursday	Friday
Dynamic Warm Up	Front Skip Slow Carioca Dot/Cross Drill	High Foot Lunge Lateral Jumping Jacks Jumping and Landing Drills	Running Mechanics Drills	Front Skips A-Skips forward A-skips lateral	Agility Ladder 2 in,2out Zig zag Nike Shuffle
Core Specific	Plank Position	Crunch/ Hyperextension Series	1.5 mi run in boots and utilities	For Time - - Run 400 m - 21 pull-ups - 9 reps 65 lb thruster - Run 400 m - 15 pull-ups - 15 reps 65 lb thruster - Run 400 m - 9 pull-ups - 21 reps 65 lb thruster	For Time - - 3 Mi Ruck March with 40 lb Pack - Push-up/Squat with pack series
Event	For time - - 800 m run - 25 med ball C&J - 600 m run - 50 med ball deadlifts - 400 m run - 75 med ball squats (hugging ball)	Complete as many rounds as possible in 20 min: - 12 reps of 65 lb push-press - 10 pull-ups	Buddy Exercise Abdomen Series	Med Ball Sit & Reach Crazy Eights Bicycles	None
Week 12 (cont.)	Monday	Tuesday	Wednesday	Thursday	Friday
Cool Down	PNF Stretching	DROM Stretching	Static Stretching	DROM Stretching	PNF Stretching

Compare to	20 lb Sandbag for MB	Complete as many Rounds as possible in 20 min: - 20 sandbag swings - 10 pull-ups	Same as above	30 reps of thrusters with 30 lb sandbag	Same as above

Appendix B. Johnson-Neyman Significance Regions

Johnson-Neyman significance regions must be computed when there is reason to believe that unit outcome differences depend on the initial level of fitness. This situation can arise when regression lines are not parallel. The basic problem can be illustrated by noting that nonparallel regression lines must cross at some point. At this point, the same value is predicted for both units, so the expected difference in outcomes is zero, a value that cannot possibly be significant. The unit differences at nearby initial fitness values will be small and can only be statistically significant if the sample size is very large. Even then, the practical importance of the differences would be questionable. The size of the differences increases as points further from the crossover value are examined. Thus, nonparallel regression lines make it necessary to ask, “For what initial values do the units differ significantly?” The Johnson-Neyman region is the answer to this question.

Rogosa (1981) provided relatively simple methods of computing the boundaries for Johnson-Neyman significance regions. In the present application, these methods identify two pretest scores as the region boundaries. The methods also determine the relationship between these boundaries and significance. One possibility is that all of the significant differences fall between the two boundary values. This outcome is referred to here as an interior significance region. The other possibility is that the significant differences are found below the lower of the two boundary values and above the higher of the two boundary values. This outcome is referred to here as an exterior significance region. When these regions are determined, it is possible for none, some, or all of the observed data points to fall in the significance regions.

Table B-1 summarizes the results of applying Rogosa’s (1981) methods to the present data. It is evident that the computations that define the regions of significant differences can define boundaries that are unrealistic. For example, the negative lower boundaries for knees to elbows and the 5-km row are examples. The upper end of the range can also be unrealistic. As an example, anyone who completed the 300-yd shuttle run in19 s would have to better the world record for the 100-m dash and continue to do so for another 200-m. Similarly, it is very unlikely that anyone will actually perform a standing broad jump of 25 ft 10 in (i.e., 310 in). Only exceptional athletes can reach this distance with a running start, so accomplishing this feat from a standing start is virtually impossible. These essentially impossible boundaries do not invalidate the method. The boundaries are theoretical. They only define the points at which differences would switch significance status *if those performance levels actually occurred*.

The preceding examples make it clear that the boundaries of Johnson-Neyman significance regions have meaning only when compared to actual performance. Table B-1 provides the information required to make this comparison for the present study. The table indicates:

1. The boundaries of the significance range are given to fix the upper and lower cutoff points for significant differences.

Table B-1. Johnson-Neyman Significance Regions

	Boundaries of Significance Range			Range of Initial Scores[a]		
Test	Lower	Upper	Region	Lower	Upper	Sig.[b]
Knees to Elbows	-2.4	37.4	Interior	0	34	All
Broad Jump	21.3	310.0	Interior	51	115	All
300-yd Shuttle Run	18.7	261.0	Interior	31	167	All
1-min Squats	10.4	151.2	Interior	13	79	All
1-min Push-ups	10.0	153.2	Interior	11	90	All
1-mi Run	2:01.7	27:45.8	Exterior	5:49	10:56	None
500-m Row	26.5	6:22.6	Interior	1:29.8	2:58.3	All
2-km Row	2:20.2	32:12.4	Exterior	6:54	14:20	None
5-km Row	-8098	852.0	Exterior	18:31.7	31:58.9	All
PFT	64.1	940.6	Interior	107	300	All

[a]The range of initial scores was defined by determining the highest and lowest scores for each test that was observed at the time of the first test. This range has been based on *all* individuals who participated in the pretesting whether or not they participated in the posttesting. This inclusion criterion ensured that the range of actual pretest values would be as wide as possible.
[b]The responses in the significance column indicate which study participants would respond differently to the two programs based on their observed initial fitness level.

2. "Region" indicates whether significant differences occur between the boundaries or outside them. An interior region means that differences are significant for all test scores *within* the lower and upper bounds (i.e., lower ≤ test score ≤ upper). An exterior region means that the unit differences are significant only for initial tests that fall *outside* the boundaries. Exterior regions divide the significant differences into two separate regions of significant differences. The lower region consists of all initial test scores below the lower boundary. The upper region consists of all initial test scores above the upper boundary.
3. Comparing the range of initial scores to the boundaries of the Johnson-Neyman significance regions determines whether none, some, or all of the test subjects would have responded differently to the two programs.

The final column of Table B-1 indicates the conclusions about unit differences in fitness based on the Johnson-Neyman regions. Either all cases fell within the region of significant differences or none of them did. In most cases, the basis for this assertion is clear. However, the 5-km row test produced a distinctive pattern. In this case, the lower bound of the region was a meaningless negative time, so there was no meaningful lower significance region. The upper bound was 14:12 min, so the training programs would produce significant differences for any individual whose time was slower than this upper bound. In fact, the *fastest* initial test time was 18:31.7 min. Thus, all of the observed times fell in the upper region of significant differences. The conclusion is that the units

produced significantly different effects for all individuals.

The computation of Johnson-Neyman significance regions makes it possible to describe unit differences unconditionally. All statements about the significance of unit differences can be made without referring to a specific range of initial test scores. Although the size of the unit differences may vary with initial fitness, the difference is significant for all observed starting points.

REPORT DOCUMENTATION PAGE

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1. Report Date (DD MM YY)
20 11 08

2. Report Type
Technical

3. DATES COVERED (from - to)
Apr 2007 – Nov 2008

4. TITLE AND SUBTITLE
An Evaluation of a Combat Conditioning Trial Program

5a. Contract Number:
5b. Grant Number:
5c. Program Element:
5d. Project Number:
5e. Task Number:
5f. Work Unit Number: 60704

6. AUTHORS
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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8. PERFORMING ORGANIZATION REPORT NUMBER
09-02

8. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES)

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10. Sponsor/Monitor's Acronyms(s)
NMRC/NMSC

11. Sponsor/Monitor's Report Number(s)

12 DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT (maximum 200 words)

Proper alignment of physical training practices with operational requirements is an ongoing concern for the U.S. Marine Corps. This alignment is being revisited in light of recent combat experiences. Greater emphasis on core strength and power are believed to be needed. A program designed specifically to develop these areas of capability was compared with usual conditioning practices. The Combat Conditioning Trial Program (CCTP) produced gains in core strength and power as intended, with no loss of cardiorespiratory fitness or upper body strength and power. The usual combat conditioning program did produce greater gains in cardiorespiratory fitness, but this trend may have been the result of relatively poor fitness when the study began. The CCTP produced a trend toward lower injury rates. The CCTP achieved its objectives of improving core strength and power without adverse effects on other areas of fitness or injury.

14. SUBJECT TERMS
functional fitness, combat conditioning, program evaluation, physical fitness

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	18a. NAME OF RESPONSIBLE PERSON
a. REPORT	b.ABSTRACT	b. THIS PAGE			Commanding Officer
UNCL	UNCL	UNCL	UNCL	40	18b. TELEPHONE NUMBER (INCLUDING AREA CODE) COMM/DSN: (619) 553-8429

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18